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ENVIRONMENTAL SUSTAINABILITY: UNIVERSAL AND NON-NEGOTIABLE[1,2]

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Abstract. After deploring the mystification of the term "sustainability" and tendencies to conflate it with society's desiderata, we desegregate three types of sustainability: social, economic, and environmental. After clarifying these three linked and overlapping concepts, and construing them with "sustainable development," we distinguish quantitative throughput growth from qualitative development, and mention intergenerational equity and scarcity of natural capital that together lead to the definition of "environmental sustainability" by the output/input rule, i.e., keep wastes within assimilative capacities; harvest within regenerative capacities of renewable resources; deplete non-renewables at the rate at which renewable substitutes are developed.

After distinguishing development from sustainability and from growth, the paper describes the concept of natural capital and uses the concept to present four alternative definitions of environmental sustainability. Next, the paper presents criteria for analyzing environmental sustainability and uses the Ehrlich-Holdren framework in which "Population," "Affluence," and "Technology" are examined separately. The paper then nuances the $I = PAT$ identity and starts to disaggregate the components of sustainability into more dynamic formulations. The final section describes how one large development agency, the World Bank, is endeavoring to incorporate these new principles into its operations.

Key words: environmental sustainability; growth vs. development; natural capital, maintenance of; population, affluence, and technology.

INTRODUCTION

Environmental sustainability (ES) is not pornography! Detractors claim ES is like pornography: "you'll know it when you see it." Sustainability must not become a landfill dump for everyone's environmental and social wish lists. Detractors are terrified of defining ES precisely because they know it would change their behavior. To postpone such a horrific result, detractors pursue two evasive actions. First is to load all desiderata—such as freedom, democracy, gender balance, equality, equity—onto the sustainability bandwagon. Second is to refuse to define ES; keep it fuzzy, they say, or keep it pornographic. Some detractors claim sustainability cannot be defined or made operational.

We seek to focus the definition of environmental sustainability (ES), partly by distinguishing ES from social sustainability and from economic sustainability. The challenge to social scientists is to produce their own definition of social sustainability, rather than load social desiderata on to the definition of ES. Similarly with economic sustainability; let economists define it or use previous definitions of economic sustainability. The three types of sustainability—social, environmental, and economic—are clearest when kept separate. They are contrasted in Table 1. While there is some overlap among the three, and certainly linkages, the three are best disaggregated and addressed separately by different disciplines. Social scientists are best able to define social sustainability, and environmentalists do not have a major role in that need. The disciplines best able to analyze each type of sustainability are different; each follows different laws and methods. It is not clarifying to heap all priorities onto a single type of sustainability.

SUSTAINABILITY AND DEVELOPMENT

Clearly these three different types of sustainability are related in parts (Table 1); however, in this paper we focus on environmental sustainability, rather than on social sustainability (SS) or economic sustainability (EcS). Here environmental sustainability (ES) is the goal; sustainable development can be one part of the means to approach that goal. We note that the moment the term "development" is introduced, the discussion becomes quite different, and murkier. Although this paper does not focus on sustainable development, we do provide a definition: *sustainable development* is development without growth in throughput of matter and energy beyond regenerative and absorptive capacities.

[1] Manuscript received 20 December 1994; revised 17 April 1995; accepted 24 April 1995; final version received 20 July 1995.

[2] For reprints of this group of papers, see footnote 1, p. 975.

TABLE 1. Comparison of social, economic, and environmental sustainability.

Social sustainability ("SS")	Economic sustainability ("EcS")	Environmental sustainability ("ES")
SS will be achieved only by systematic community participation and strong civil society. Social cohesion, cultural identity, diversity, sodality, comity, sense of community, tolerance, humility, compassion, patience, forbearance, fellowship, fraternity, institutions, love, pluralism, commonly accepted standards of honesty, laws, discipline, etc., constitute the part of *social capital* that is least subject to rigorous measurement, but probably most important for SS. This "moral capital," as some have called it, requires maintenance and replenishment by shared values and equal rights, and by community, religious, and cultural interactions. Without this care it will depreciate just as surely as will physical capital. *Human capital*—investments in the education, health, and nutrition of individuals—is now accepted as part of economic development (WDR 1990, 1991, 1992, 1995), but the creation of social capital, as needed for SS, is not yet adequately recognized.	The widely accepted definition of economic sustainability is "*maintenance of capital*", or keeping capital intact, and has been used by accountants since the Middle Ages to enable merchant traders to know how much of their sales receipts they and their families could consume. Thus the modern definition of income (Hicks 1946) is already sustainable. Of the four forms of capital (human-made, natural, social, and human), economists have scarcely at all been concerned with *natural capital* (e.g., intact forests, healthy air) because until relatively recently it had not been scarce. Economics also prefers to value things in monetary terms, so it is having major problems valuing natural capital—intangible, intergenerational, and especially common-access resources, such as air, etc. In addition, environmental costs used to be "externalized," but are now starting to be internalized through sound environmental policies and valuation techniques. Because people and irreversible impacts are at stake, economics has to use anticipation and the precautionary principle routinely, and should err on the side of caution in the face of uncertainty and risk.	Although ES is needed by humans and originated because of social concerns, ES itself seeks to improve human welfare and SS by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans. Humanity must learn to live within the limitations of the biological and physical environment, both as a provider of inputs ("sources") and as a "sink" for wastes (Serageldin 1993). This translates into holding waste emissions within the assimilative capacity of the environment without impairing it. It also means keeping harvest rates of renewables to within regeneration rates. Quasi-ES can be approached for non-renewables by holding depletion rates equal to the rate at which renewable substitutes can be created (El Serafy 1991). ES means maintaining natural capital, akin to the definition of EcS.

Carrying capacity (CC) is another concept that needs definition; Daily and Ehrlich (1992:761–771) explicate it in the most effective way—their ecologist's definition (p. 762) of *carrying capacity* is: "the maximal population size of a given species that an area can support without reducing its ability to support the same species in the future." But for humans, CC must be disaggregated into Biophysical CC and Social CC, parallel to the distinction between ES and SS. Our definition thus hinges on distinguishing between growth and development. According to Boutros-Ghali (1994:1) development is a "fundamental human right" that requires *inter alia* democracy and good governance. "Economic growth is the engine of development. . . . sustained economic growth." This definition does not distinguish between the different concepts of growth and development. While development can and should go on indefinitely for all nations, throughput growth cannot. Sustainability will be achieved only when development supplants growth. Acknowledging the finite nature of our planet, "sustainable growth" is a bad oxymoron (Daly 1991).

Recent emphases on such topics as social development, economic development, development with equity, and development and basic needs suggests that "development" could become so vague as to require a sanctifying adjective. These topics should be carefully distinguished and defined anew by others; that is a challenge for development specialists, not for environmentalists. The priorities of development are usually said to be the reduction of poverty, illiteracy, hunger, and disease. While these goals are fundamentally important, they are quite different from the goals of environmental sustainability, namely maintaining environmental sink and source capacities unimpaired. But "environmental sustainability" as a topic is legitimized by the Boutros-Ghali (1994) pronouncement on economic development, and is the focus of this paper.

The tacit goal of economic development is to narrow the equity gap between the rich and the poor. Almost always this is taken to mean raising the bottom (i.e., enriching the poor), rather than lowering the top, or undertaking redistribution (Haavelmo and Hansen 1992). Only very recently is it becoming admitted that bringing the low-income countries up to the affluence levels found in OECD (Organisation for Economic Co-operation and Development) countries, in 40 or even 100 years, is a totally unrealistic goal. We do not want to be accused of attacking a straw man—who ever claimed that global equality at current OECD levels was possible? However, most politicians and most citizens have not yet accepted the unrealistic nature of this goal. Most people would accept that it is *desirable* for low-income countries to be as rich as the North—and then leap to the false conclusion that it must therefore be *possible*! They are encouraged in this non sequitur by the realization that if greater equality cannot be attained by growth alone, then sharing and population stability will be necessary. Politicians find it easier to revert to wishful thinking than to face those two issues. Once we wake up to reality, however, there is no further reason for dwelling on the impossible, and every reason to focus on what *is* possible.

One can make a persuasive case (see Serageldin 1993*b*:141–143) that achieving per capita income levels in low-income countries of U.S.$1500 to $2000 (rather than $21 000) is quite possible. Moreover, that level of income may provide 80% of the basic welfare provided by a $20 000 income—as measured by life expectancy, nutrition, education, and other measures of social welfare. This tremendously encouraging case remains largely unknown, even in development circles. It needs to be widely debated and accepted as the main goal of development. Its acceptance would greatly facilitate the transition to ES. But to accomplish the possible parts of the imperative of development, we must stop idolizing the impossible. We leave the discussion of development at this point and repeat the challenge to development specialists to deepen this important argument.

The paramount importance of sustainability arose partly because, as mentioned, the world is starting to recognize that current patterns of economic development are not generalizable. Present patterns of OECD per capita resource consumption and pollution cannot possibly be generalized to all currently living people, much less to future generations, without liquidating the natural capital on which future economic activity depends. Sustainability thus arose from the recognition that the profligate and inequitable nature of current patterns of development, when projected into the not-too-distant future, lead to biophysical impossibilities. The transition to sustainability is urgent because the deterioration of global life-support systems—the environment—imposes a time limit. We do not have time to dream of creating more living space or more environment, such as colonizing the moon or building cities beneath the sea; we must save the remnants of the only environment we have, and allow time for, and invest in the regeneration of, what we have already damaged.

Growth Compared with Development

Consider the dictionary distinction between growth and development: (1) *To grow* means to "increase in size (amount, degree) by assimilation"; (2) *To develop* means to "expand, bring out potentialities, capabilities; to advance from a lower to a higher state" (Funk & Wagnall's Standard Desk Dictionary, 1980, T. Y. Crowell, New York, New York, USA). These definitions are useful in conceptualizing sustainability in that development is sustainable, and throughput growth is not. This is unrelated to the unhelpful "development vs. environment" perception of a policy trade-off. True, "growth" refers to added value, but sustainability demands that we disaggregate what part of the value-added increase is due to quantity change (throughput) and what part to qualitative improvement.

It is neither ethical nor helpful to the environment to expect poor countries to cut or arrest their development, which tends to be highly associated with throughput growth. Poor, small, developing economies need both growth and development. Therefore, the rich countries, which are responsible for most of today's global environmental damage (e.g., CO_2 accumulation, ozone-shield damage), and whose material well being can sustain halting or even reversing throughput growth, must take the lead in this respect. Most local environmental damage (e.g., soil erosion, water pollution) occurs in developing countries. Poverty reduction will require considerable growth, as well as development, in developing countries. But global environmental constraints are real, and more growth for the South must be balanced by negative throughput growth for the North if environmental sustainability is to be achieved. Future Northern growth should be sought from productivity increases in terms of throughput (e.g., reducing the energy intensity of production).

Development by the North must be used to free resources (source and sink functions of the environment) for growth and development so urgently needed by the poorer nations. Large-scale transfers to the poorer countries also will be required, especially as the impact of economic stability in the North countries may depress terms of trade and lower economic activity in developing countries. Higher prices for the exports of poorer countries, as well as debt relief, will therefore be required. Most importantly, population stability is essential to reduce the need for growth everywhere, especially where population growth has the greatest impact (i.e., in Northern high-consuming nations; there the population has a doubling time of 162 yr) as well as where population growth is highest (i.e., in the poor, low-consuming countries, with a population doubling time of only 30 yr, exclusive of China).

Natural Capital and Sustainability

Intergenerational and intragenerational sustainability

Sustainability in economic terms can be described as the "maintenance of capital," sometimes phrased as "non-declining capital." Historically, at least as early as the Middle Ages the merchant traders used the word "capital" to refer to human-made capital. The merchants wanted to know how much of their trading ships' cargo sales receipts could be consumed by their families without depleting their capital. Economics Nobelist Sir John Hicks encapsulated the sustainability concept in 1946 when he defined income as the amount (whether natural or financial capital) one could consume during a period and still be as well off at the end of the period. Solow (1991) is vaguer; to him sustainability is an obligation or injunction "... to conduct ourselves so that we leave to the future the option or the capacity to be as well off as we are ... not to satisfy ourselves by impoverishing our successors. ..."

Today's OECD societies have already impoverished much of the world. Most people in the world today are already impoverished or barely above subsistence and can by no stretch of the imagination ever be as well off as the OECD average. Our successors or future generations seem more likely to be more numerous and poorer than today's generation. Sustainability indeed has an element of not harming the future (intergenerational equity), but only addressing the future element diverts attention from today's lack of sustainability (intragenerational equity). If the world cannot move towards intragenerational sustainability for this generation it will be greatly more difficult to achieve intergenerational sustainability in the future. This is partly because the world is hurtling away from environmental sustainability (ES) today. Environmental source and sink capacities are being impaired. This means the capacity of these environmental services in the future will be lower than today. The second reason for tackling intragenerational sustainability first is that world population soars by 100×10^6 new souls each year, some of them OECD over-consumers, many of them poverty stricken. This means achieving intergenerational equity is more difficult each year that has a bigger generation.

Of the various forms of capital mentioned above, "environmental sustainability" refers to natural capital. So defining environmental sustainability includes at least two further terms, namely "natural capital" and "maintenance" or at least "non-declining." *Natural capital* is basically our natural environment, and is defined as the stock of environmentally provided assets (such as soil and its microbes and fauna (Pimentel et al. 1992), atmosphere, forests, water, wetlands) that provides a flow of useful goods or services. The flow of useful goods and services from natural capital can be renewable or non-renewable, and marketed or non-marketed. Sustainability means maintaining environmental assets, or at least not depleting them. "Income" is sustainable by the generally accepted definition of Hicks (1946): "the maximum value a person can consume during a week, and still expect to be as well off at the end of the week as at the beginning." Any consumption that is based on the depletion of natural capital should not be counted as income. Prevailing models of economic analysis tend to treat consumption of natural capital as income, and therefore tend to promote patterns of economic activity that are unsustainable. Consumption of natural capital is liquidation, the opposite of capital accumulation.

Natural capital is distinguished from manufactured and human or social capital. *Manufactured capital* includes houses, roads, factories, and ships. *Human or social capital* includes people, their capacity levels, institutions, cultural cohesion, education, information, and knowledge.

Human capital formation, by convention, is left out of the national accounts (the United Nations System of National Accounts, SNA) for various reasons, one of which is that, if it is truly productive, it will eventually be reflected, through enhanced productivity, in a higher gross domestic product (GDP). Realization of the values of education and administration, for example, are lagged, and are conventionally assumed to be equal to their costs. The loss of natural capital, if not recorded—as is largely the case today—may take some time before it will reflect itself in income and productivity measurements.

From the mercantilists until very recently "capital" referred to the form of capital in the shortest supply, namely manufactured capital. Investments were made in the limiting factor, such as sawmills and fishing boats, because their natural capital complements—forests and fish—were abundant. That idyllic era has ended.

Now that the environment is so heavily used, the limiting factor for much economic development has become natural capital as much as man-made capital. In some cases, like marine fishing, it has become *the* limiting factor—fish have become limiting, rather than fishing boats. Timber is limited by remaining forests, not by saw mills; petroleum is limited by geological deposits and atmospheric capacity to absorb CO_2, not by refining capacity. As natural forests and fish populations become limiting we begin to invest in plantation forests and fish ponds. This introduces a hybrid category that combines natural and human-made capital—a category we may call "cultivated natural capital." Thus, the subcategory of marketed natural capital, intermediate between human capital and natural capital, is *cultivated natural capital* such as agriculture products, pond-bred fish, cattle herds, and plantation forests. This category is vital to human well being, accounting for most of the food we eat, and a good deal of the wood and fibers we use. The fact that humanity has the capacity to "cultivate" natural capital dramatically expands the capacity of natural capital to deliver services. But cultivated natural capital (agriculture) is decomposable into human-made capital (e.g., tractors, diesel irrigation pumps, chemical fertilizers) and natural capital (e.g., topsoil, sunlight, water). Eventually the natural capital proves limiting.

Natural capital is now scarce

In an era in which natural capital was considered infinite relative to the scale of human use, it was reasonable not to deduct natural-capital consumption from gross receipts in calculating income. That era is now past. The goal of environmental sustainability is thus the conservative effort to maintain the traditional meaning and measure of income in an era in which natural capital is no longer a free good, but is more and more the limiting factor in development. The difficulties in applying the concept arise mainly from operational problems of measurement and valuation of natural capital, as emphasized elsewhere in this paper, and by Ahmad et al. (1989), Lutz (1993), and El Serafy (1991, 1993).

Four degrees of environmental sustainability

Sustainability can be divided into four degrees—weak, intermediate, strong, and absurdly strong—depending on how much substitution one thinks there is among types of capital (Daly and Cobb 1994). We recognize that there are at least four kinds of capital: Human-made (the one usually considered in financial and economic accounts), natural capital (as defined previously, and leaving for the moment the case of cultivated natural capital), human capital (investments in education, health and nutrition of individuals), and social capital (the institutional and cultural basis for a society to function).

Weak sustainability.—This means maintaining total capital intact without regard to its composition from among the four different kinds of capital (natural, human-made, social, or human). This would imply that the different kinds of capital are perfect substitutes, at least within the boundaries of current levels of economic activity and resource endowment. Given current gross inefficiencies in resource use, weak sustainability would be a vast improvement as a welcome first step—but would by no means constitute—ES (environmental sustainability).

Weak sustainability means we could convert all or most of the world's natural capital into human-made capital or artifacts and still be as well off. (Human and social capital is largely lost at death so has to be renewed each generation). We disagree; society would be worse off (fewer choices) because natural and human-made capital are not perfect substitutes. On the contrary, they are complements to a great extent.

Intermediate sustainability.—This would require that in addition to maintaining the total level of capital intact, attention should be given to the composition of that capital from among natural, manufactured, and human. Thus oil may be depleted as long as the receipts are invested in other capital elsewhere (e.g., in human capital development, or in renewable energy resources), but, in addition, efforts should be made to define critical levels of each type of capital, beyond which concerns about substitutability could arise and these should be monitored to ensure that the patterns of development do not promote a total decimation of one kind of capital no matter what is being accumulated in the other forms of capital. This assumes that while manufactured and natural capital are substitutable over a sometimes significant but limited margin, they are complementary beyond that limited margin. The full functioning of the system requires at least a mix of the different kinds of capital. Since we do not know exactly where the boundaries of these critical limits for each type of capital lie, it behooves the sensible person to err on the side of caution in depleting resources (especially natural capital) at too fast a rate. Intermediate sustainability is a big improvement over weak sustainability and seems "sensible." Its great weakness is that it is difficult if not impossible to define critical levels of each type of capital, or rather each type of natural capital that is the limiting factor. We suspect that if the levels of the different types of natural capital become reliably defined, intermediate sustainability would approximate strong sustainability.

Strong sustainability.—This requires maintaining different kinds of capital intact separately. Thus, for natural capital, receipts from depleting oil should be invested in ensuring that energy will be available to future generations at least as plentifully as enjoyed by the beneficiaries of today's oil consumption. This assumes that natural and human-made capital are not really substitutes but complements in most production functions. A sawmill (human-made capital) is worthless without the complementary natural capital of a forest. The same logic would argue that if there are to be reductions in one kind of educational investments they should be offset by other kinds of education, not by investments in roads. Of the four degrees of sustainability, we prefer strong sustainability.

Absurdly strong sustainability.—This would never deplete anything. Non-renewable resources—absurdly—could not be used at all; for renewables, only net annual growth rates could be harvested, in the form of the overmature portion of the stock.

The choice between intermediate and strong sustainability highlights the trade-offs between human-made capital and natural capital. Economic logic requires us to invest in the limiting factor, which now is often natural rather than manufactured capital, which was itself limiting yesteryear. Investing in natural capital (non-marketed) is essentially an infrastructure investment on a grand scale, that is the biophysical infrastructure of the entire human niche. Investment in such "infra-infrastructure" maintains the productivity of all previous economic investments in human-made capital, public or private, by rebuilding the natural capital stocks that have come to be limiting. Operationally, this translates into three concrete actions as follows:

1) Regeneration—Encouraging the growth of natural capital by reducing our level of current exploitation of it;

2) Relief of Pressure—Investing in projects to relieve pressure on natural capital stocks by expanding

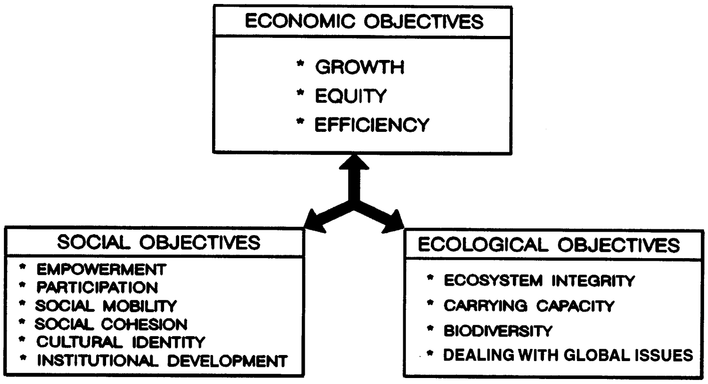

FIG. 1. The three goals (objectives) of economic development, and how they compare to social and ecological objectives. (Modified from Serageldin 1993*a, b.*)

cultivated natural capital, such as tree plantations to relieve pressure on natural forests; and

3) Increase of Efficiency—Increasing the efficiency of (a) products (such as improved cookstoves, solar cookers, wind pumps, solar pumps, manure rather than chemical fertilizer), (b) infrastructure services (such as mulching toilets rather than conventional sewage treatment), and (c) lifestyle (such as less carnivorous diets).

Criteria for environmental sustainability

From the maintenance-of-natural-capital approach to environmental sustainability (ES), we can draw practical rules of thumb to guide the design of sustainable economic development. As a first approximation, the design of investment strategies should be compared with the input and output rules of ES in order to assess the extent to which a project is sustainable. At the next level of detail, specific indicators of environmental sustainability can be used, such as those the World Bank is preparing.

The implications of implementing environmental sustainability are immense. We must learn how to manage the renewable resources for the long term; we have to reduce waste and pollution; we must learn how to use energy and materials with scrupulous efficiency; we must learn how to use solar energy economically (Pimentel et al. 1994); and we must invest in repairing the damage, as much as possible, done to Earth in the past few decades by unthinking industrialization in many parts of the globe. Environmental sustainability needs enabling conditions that are not themselves integral parts of environmental sustainability; ES needs not only economic and social sustainability (Table 1, Fig. 1) but also democracy, human resource development, empowerment of women, and much more investment in human capital than is common today (i.e., increased literacy, especially ecoliteracy, Orr 1992).

As can be seen by the World Bank's recent extraordinary expansion of its traditional investments in human capital, its concerns with governance and promotion of the civil society (forms of investment in social capital), and its growing concern with natural capital and its maintenance, the Bank is increasingly tackling an agenda that tends towards promoting environmental sustainability (see *A dynamic formulation . . .*, below). The World Bank considers environmental sustainability to be an urgent priority.

The sooner we start to approach environmental sustainability the easier it will become. For example, the demographic transition took a century in Europe, but only a decade in Taiwan: technology and education make big differences. But the longer we delay, the worse will be the eventual quality of life (e.g., fewer choices, fewer species, more risk), especially for the poor who do not have the means to insulate themselves from the negative effects of environmental degradation. Immigration to the New World was a major choice for Europe, accelerating its demographic transition. Immigration has now all but halted worldwide as a demographic safety valve.

Many writers have expressed concern that the world is hurtling away from environmental sustainability at present (Simonis 1990, Meadows et al. 1992, Hardin 1993, Brown et al. 1994), although consensus has not yet been reached. But what is not contestable is that the current modes of production prevailing in most parts of the global economy are causing the exhaustion and dispersion of a one-time inheritance of natural capital, such as topsoil, groundwater, tropical forests, fisheries, and biodiversity. The rapid depletion of these essential resources, coupled with the degradation of land and atmospheric quality, show that the human economy, as currently configured, is already inflicting serious damage on global supporting ecosystems and is probably reducing future potential biophysical carrying capacities by depleting essential natural-capital stocks (Daily and Ehrlich 1992).

Yet, what is galling is that in spite of spending capital inheritance rather than just income, most of the world consumes at barely subsistence levels. Can humanity attain a more equitable standard of living that does not exceed the carrying capacity of the planet? The transition to environmental sustainability *will* inevitably occur. However, whether nations will have the wisdom and foresight to plan for an orderly and equitable transition to environmental sustainability, rather than allowing biophysical limits to dictate the timing and course of this transition, remains in doubt.

It is obvious that if pollution and environmental degradation were to grow at the same rate as economic activity, or even population growth, the damage to ecological and human health would be appalling, and the growth itself would be undermined and even self-defeating. Fortunately, this is not necessary. A transition to sustainability is possible, although it will require changes in policies and the way humans value things. The key to the improvement of the well being of millions of people lies in the increase of the added value of output after properly netting out all the environmental costs and benefits and after differentiating between the stock and flow aspects of the use of natural resources. In our view, this is the key to sustainable development. Without this needed adjustment in thinking and measurement, the pursuit of economic growth that does not account for natural capital and counts depletion of natural capital as an income stream will not lead to a sustainable development path.

The global ecosystem, which is the source of all the resources needed for the economic subsystem, is finite and has now reached a stage where its regenerative and assimilative capacities have become very strained. It looks inevitable that the next century will witness double the number of people in the human economy, depleting sources and filling sinks with their increasing wastes. If we emphasize the latter, it is because human experience seems to indicate that we have tended to overestimate the environment's capacity to cope with our wastes, even more than we overestimated the "limitless" bounty of such resources as the fish in the sea.

The Basic Conditions for Environmental Sustainability

The fundamental definition of environmental sustainability is contained in the input–output rule as follows:

Output Rule: Waste emissions from a project should be within the assimilative capacity of the local environment to absorb without unacceptable degradation of its future waste-absorptive capacity or other important services.

Input Rule: (a) *Renewables:* harvest rates of renewable-resource inputs should be within the regenerative capacity of the natural system that generates them. (b) *Non-renewables:* depletion rates of non-renewable-resource inputs should be equal to the rate at which renewable substitutes are developed by human invention and investment. Part of the proceeds from liquidating non-renewables should be allocated to research in pursuit of sustainable substitutes. (For a theoretical development of this idea, see El Serafy [1991, 1993] and Dasgupta and Heal [1979].)

Building on the economic definition of sustainability as "non-declining wealth per capita," and since wealth is so difficult to measure, environmental sustainability is now defined by the two fundamental environmental services—the source and sink functions—that must be maintained unimpaired during the period over which sustainability is required. While this general definition is robust—and irrespective of country, sector, or epoch—it can in turn be disaggregated.

The emphasis on maintenance is to be expected, first for intergenerational equity. Our descendants should have as much choice as we have. Second, as scale increases or matures, production is no longer for growth but for maintenance. "Production" is the maintenance cost of the stock and should be minimized (Daly 1994). Sustainability demands that production and consumption be equal so that we maintain capital stocks. Efficiency demands that the maintenance cost (production equal to consumption) be minimized, given the capital stock.

The basic conditions for environmental sustainability can be summarized as follows:

A) Environmental sustainability requires four related conditions of economic sustainability:

1) Maintenance of per capita manufactured capital (e.g., artifacts, infrastructure), per capita.
2) Maintenance of renewable natural capital (e.g., healthy air and soils, natural forests, oceanic fish stocks), per capita.
3) Maintenance of per capita non-renewable substitutable natural capital, with capital values based on the value of the services of the present stock of natural capital. For example, this means that if the cost of supplying energy substitutes rises, sufficient capital must be accumulated to maintain these services.
4) Maintenance of non-substitutable, non-renewable natural resources (e.g., waste absorption by environmental sink services). No depletion or deterioration of non-substitutable non-renewable natural capital. This means no net increases in waste emissions beyond absorptive capacity.

B) All economic consumption should be priced to reflect full cost of all capital depletion, including waste creation, the cost of which is equal to the cost of reducing an equivalent amount of that particular waste.

C) Stating the conditions in per capita terms calls attention to the importance of stopping population growth. Theoretically, the per capita stock of all kinds of capital could remain constant as long as the stocks grew at the same rate as population. But in actuality the rate of growth of population and stocks of physical wealth must move toward zero.

To stop throughput of matter and energy from growing or hold throughput constant (we leave until later the need actually to reduce throughput) means stabilizing population on the demand side, and improving resource productivity or "dematerializing" the economy on the supply side. Sustainability does not imply optimality. Sustainability is a necessary but not sufficient condition of optimality (Daly 1994). Resource productivity has increased already, although more progress is possible and needed. Such progress would include improvements in energy efficiency; more production with less energy and fewer materials; tight recycling; repair; re-use; and "decarbonization," another name of the transition to renewables such as wind, solar energy, and the hydrogen economy.

Some Common Misconceptions about Environmental Sustainability (ES)

Is ES the same as sustained yield?

No, clearly not. There is a lively debate, especially in forestry and fishery circles, whether ES is "sustained yield" (SY), in the form of timber removals from forest for example. Clearly ES includes, but certainly is far from limited to, sustained yield. ES is more akin to the simultaneous SY of many interrelated populations in an ecosystem. SY is often used in forestry and fisheries to determine the optimal—most profitable—extraction rate of trees or fish. ES counts all the natural services of the sustained resource. SY counts only the service of the product extracted, and ignores all other natural services. SY forestry counts only the timber value extracted; ES forestry counts all services—for example: protecting vulnerable ethnic-minority forest dwellers, biodiversity, genetic values, intrinsic as well as instrumental values, climatic, wildlife, carbon balance, water source and water moderation values, and, of course, timber extracted. The relation between the two is that if SY is actually achieved, then the stock resource (e.g., the forest) will be nearer sustainability than if SY is not achieved. SY in tropical forestry is doubtful now (Ludwig 1993), and will be more doubtful in the future, as human population pressures intensify. But even were SY to be achieved, that resource is unlikely to have also attained environmental sustainability. The optimal solution for a single variable, such as SY, usually (possibly inevitably) results in declining utility or declining natural capital sometime in the future, and therefore is not sustainable.

Is ES a variable, or a constant?

ES is a variable, but it changes so slowly that it is probably best to assume it is constant as a first approximation. If humans evolve lungs that can use hitherto unbreathably polluted air, or if we carry cylinders of oxygen on our backs, then ES is a variable. On the output side, in general, assimilative capacity cannot be substantially increased. As "waste is our fastest growing resource" this is significant. On the non-renewable input side, non-renewables can be used slower or more efficiently, or more ores and substitutes can be found, but the stock of non-renewables is fixed and cannot be increased. Technology and efficiency squeeze more utility out of inputs, but do not increase the stock. It is difficult to get renewables to regenerate faster! Even well-fertilized and irrigated trees in the United States, for example, grow slower than *laissez faire* trees in Costa Rica, which has a short winter. Light is often more limiting than water and nutrients. Human-made capital such as pond fish, and intensive agriculture such as sugarcane or hydroponic laboratory greenhouse crops have reached high levels of productivity, but the ability to get the whole of humanity to produce effectively and in an environmentally sensitive fashion and match performances achievable on experimental farms is another question. So again, ES appears to be more constant than variable—i.e., a very slowly changing variable. This is why we suggest ES is universal.

Is ES more of a concern for developing countries?

Not really, no. ES is even more relevant to industrial countries than to developing countries. The big difference is in burden sharing. The North is responsible for the overwhelming share of global environmental damage, and it is unlikely that poor countries will want to move towards sustainability if the North does not do so first. The North can contribute more to decreasing the global-warming risks by reducing greenhouse gas emissions, and the release of substances such as CFCs that damage the ozone shield. The North has to adapt to ES more than the South, and arguably before the South. The North can afford to exert leadership on itself. But because developing economies depend to a much greater extent than OECD economies on natural resources, especially renewables, the South has much to gain from reaching ES. Soil erosion, deforestation, and water pollution occur more in developing countries, which shows how unsustainable they too are. In addition, because much tropical environmental damage is either impossible or more expensive to rehabilitate than that in temperate environments, the South will gain from a preventive approach, rather than emulating the curative approach and similar mistakes of the North.

Does ES imply reversion to autarky or the stone age?

Certainly not; ES is not sacrifice. On the contrary, ES increases welfare. The message that affluence and overconsumption do not increase welfare is being acted on by a few people. It is important to recognize the overriding importance of poverty alleviation first. As the diseases of overconsumption increase (heart attack, stroke), this message will spread. The concept of sufficiency (doing more with less) needs dissemination. Education is needed that love, pleasure, fulfillment, enjoyment, and other rewards do not depend on over consumption, but in fact are decreased by it.

A single measure—population times per capita consumption of natural capital—encapsulates an essential dimension of the relationship between economic activ-

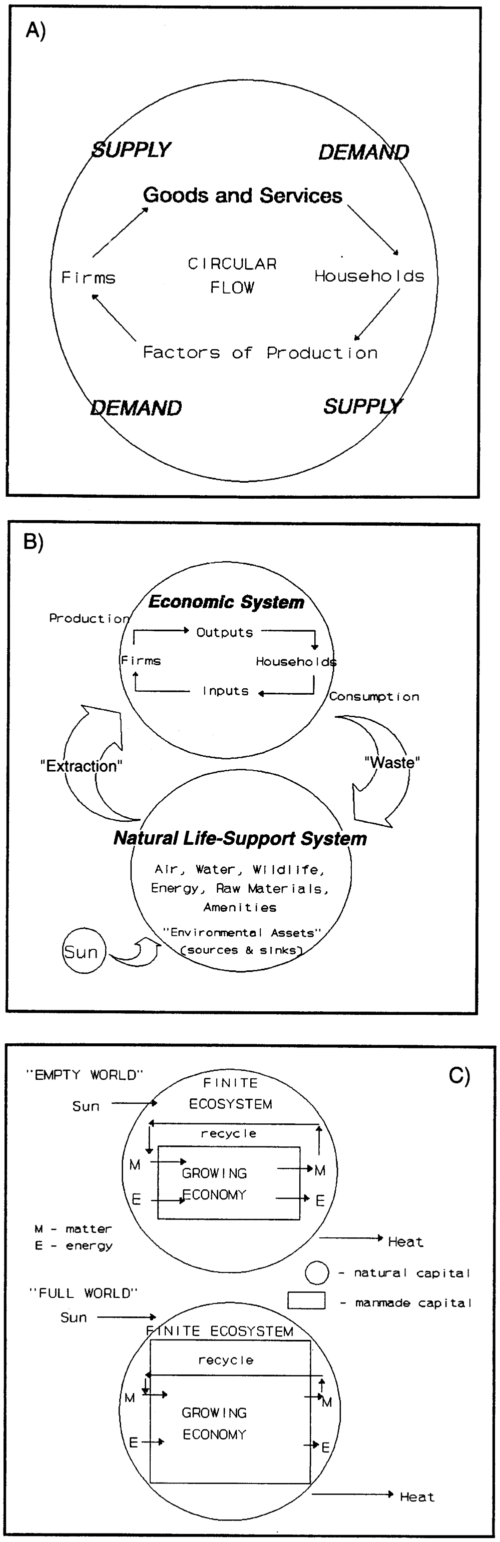

FIG. 2. Schematic depictions of the economic and environmental systems and their relationships. (A) The economy as an isolated system. (B) Linking the economic and environmental systems. (Modified from Tietenberg 1992.) (C) The economy as dependent on the environment.

ity and environmental sustainability. This scale of the growing human economic subsystem is judged, whether large or small, relative to the finite global ecosystem on which it so totally depends, and of which it is a part. The global ecosystem is the source of all material inputs feeding the economic subsystem, and is the sink for all its wastes. Population times per capita consumption of natural capital is the total flow—*throughput*—of resources from the global ecosystem to the economic subsystem, then back to the global ecosystem as waste (as illustrated in Fig. 2B). In the long-gone "empty-world" case (Fig. 2C: top), the scale of the human economic subsystem is small relative to the large, but non-growing, global ecosystem; in the "full-world" case (Fig. 2C: bottom), the scale of the human economic subsystem is large and still growing, relative to the finite global ecosystem. In the full-world case, the economic subsystem has already started to interfere with global ecosystem processes, such as altering the composition of the atmosphere (Greenhouse warming), or the now nearly global damage to the ozone shield.

POPULATION, AFFLUENCE, AND TECHNOLOGY

Carrying capacity is a measure of the amount of renewable resources in the environment in units of the number of organisms these resources can support. It is thus a function of the area and the organism: a given area could support more lizards than birds with the same body mass. Carrying capacity is difficult to estimate for humans because of major differences in affluence, behavior, and technology. An undesirable "factory-farm" approach could support a large human population at the lowest standards of living; certainly the maximum number of people is not the optimum. The higher the throughput of matter and energy, or the higher the consumption of environmental sources and sinks, the fewer the number of people that can enjoy it.

Ehrlich and Holdren (1974) encapsulate the basic elements of this concept in a simple and forceful, though static, presentation: The impact (I) of any population or nation upon environmental sources and sinks is a product of its population (P), its level of affluence (A), and the damage done by the particular technologies (T) that support that affluence:

$$I = P \times A \times T,$$

or alternatively

$$I \equiv P \times Y/P \times I/Y,$$

where "population" (P) refers to human numbers, "affluence" (Y/P) is output (Y) per capita, and "technology" (I/Y) refers to environmental impact per unit of output, i.e., a dollar's worth of solar heating stresses the environment less than a dollar's worth of heat from a lignite-fired thermal power plant.

Early studies of environmental limits to human activities emphasized the limits to environmental resources (i.e., petroleum, copper, etc.) Experience has shown, however, that these limits were exaggerated, and that the sink constraints (i.e., waste assimilation such as air and water pollution, greenhouse gases and ozone depletion, etc.) are more stringent.

There are a number of ways of reducing the impacts of human activities upon the environment. These include changing the structure of production and demand (i.e., more high-value, low-throughput production and service industries) and investing in environmental protection (e.g., for the amenity value, if for nothing else). Reducing impacts of human activities upon the environment can be achieved only by change in the three variables in the equation. Reducing impact (I) means either (1) limiting population growth; or (2) limiting affluence; or (3) improving technology, thereby reducing throughput intensity of production. There is much to be done to limit the impact of human activities upon the environment, although so far many of the measures have proven politically unpopular and difficult to achieve. The changes in variables—population, affluence, technology—through which I can be limited, are each examined in more detail below.

Population

Population stability is fundamental to environmental sustainability. Today's 6×10^9 people are increasing by nearly 100×10^6 individuals a year. Just the basic maintenance of 100×10^6 extra people per year needs an irreducible minimum of throughput in the form of clothing, housing, food, and fuel. There is so much momentum in population growth that even under the United Nations' most optimistic scenario, the world's population may level off at 11.6×10^9 persons in 2150! Since under current inequitable patterns of production, consumption, and distribution we have not provided adequately for one fifth of humanity at today's relatively low population, the prospects for being either able or willing to provide better for double that number of people look grim indeed, unless major changes in attitudes and practices were to happen. We do not want to cast a political problem (willingness to share) as a biophysical problem (encountering limits to total product). We urge much greater sharing. However, we do not want to make the opposite error of suggesting that more equitable sharing will permit us completely to avoid the issue of biophysical limits to total production in the face of mounting population pressure. Responsible stewardship of the earth requires that we redouble efforts to slow down population growth, especially in overconsuming countries, as well as in the poorest and most vulnerable countries, where population is currently growing fastest and people are suffering most.

The human population is totally dependent on energy from the sun, fixed by green plants, for all food, practically all fiber (cotton, wool, paper), most building materials (wood), and most of the cooking and heating fuels in many developing countries (fuel wood). The human economic subsystem now appropriates 40% of all that energy, according to Vitousek et al. (1986). Yet the sun provides enough energy to cover 6500 times the total commercial energy consumption of the world. Instead of harnessing this massive source of clean and renewable energy, the bulk of energy research funds are still going to nuclear energy. This speaks poorly for the priorities of energy research worldwide and is a measure of how far we still have to go to get the concept of sustainability thoroughly incorporated into the priorities of those allocating the energy research dollars.

Whether the issue will be joined over the energy fixed by photosynthesis or not, there are reasons to be concerned. Several factors are all working in the same direction to reduce irreversibly the energy available globally through plants. Greenhouse warming, damage to the ozone shield, and less predictable, unstable climates seem inescapable and may all have started. Depending on the models used, these will reduce agricultural, forest, fisheries, rangeland, and other yields. The increases in ultraviolet-B (UVB) light reaching the earth through the damaged ozone shield may decrease the carbon-fixing rates of marine plankton, one of the biggest current carbon sinks. In addition, UVB light may damage young or germinating crops. According to some reports, tiny temperature elevations have already begun to increase the decomposition rates of the vast global deposits of peats, soil organic matter, and muskeg, thus releasing stored carbon. Only in mid-1992 did the circumboreal muskeg and tundra become net global carbon sources (instead of being net C-sinks). A substantial and increasing number of atmospheric scientists claim that an immediate 50% reduction in global fossil fuel use is necessary to stabilize atmospheric composition. Whether one accepts this estimate or not, it dramatizes the gravity of the situation.

Affluence

Overconsumption by the OECD countries contributes more to some forms of global unsustainability than does population growth in low-income countries (Mies 1991, Parikh and Parikh 1991). If energy consumption is used as a crude surrogate for environmental impact on Earth's life-support systems, (crude since the type of energy used is not taken into account), then "A baby born in the United States represents twice the impact on the Earth as one born in Sweden, three times one born in Italy, 13 times one born in Brazil, 35 times one in India, 140 times one born in Bangladesh or Kenya, and 280 times one born in Chad, Rwanda, Haiti or Nepal" (Ehrlich and Ehrlich 1989*a, b*). Although Switzerland, Japan, and Scandinavia, for example, have recently made great progress in reducing the energy intensity of production, the key question is: can humans lower their per capita impact (mainly in OECD countries) at a rate sufficiently high to counterbalance their explosive increases in population (mainly in low-income countries)? The affluent are reluctant to acknowledge the concept of sufficiency—to begin emphasizing quality and non-material satisfactions. Redistribution from rich to poor on any significant scale is, at present, felt to be politically impossible. But the questions of increasing equity in sharing the earth's resources and its bounty must be forcefully put on the table.

Increased affluence, especially of the poor, thus need not inevitably hurt the environment. Indeed, used wisely, economic growth can provide the resources needed to protect and enhance the environment in the poorest developing countries where environmental damage is caused as much by the lack of resources as it is by rapid industrialization. Indeed, if poor countries are to have any hope of protecting their natural capital, accelerated economic and human development is imperative. Thus, there is a nexus of problems linking poverty, environmental degradation, and rapid population growth. Breaking this nexus of problems is essential if the poor are not to continue to be the victims, as well as the unwitting cause, of environmental degradation.

Technology

Technology continues to play a vital role in driving a wedge between economic activity and environmental damage. Illustrations of this occur in virtually every field of human activity.

The main means to accelerate the two crucial transitions—to population stability and to renewable energy—are:

1) Human capital formation—Education and training, and employment creation, particularly for girls equivalent to that for boys; meeting unmet family-planning demand.

2) Technological transfer—For the South and East to leapfrog the North's environmentally damaging stage of economic evolution. For the developing countries, this requires creating an incentive framework conducive to efficient investment. For industrial countries, this requires an open trade regime and adequate investment in new, cleaner technologies.

3) Direct poverty alleviation—Including social safety nets, and targeted aid (inter alia see World Bank 1990, Goodland and Daly 1993*a*, *b*).

In energy, for example, the introduction of mechanical and electrical devices in power generation over the past four decades has reduced particulate emissions per unit of energy generated by up to 99% and newer technologies, such as flue-gas desulfurization and fluidized-bed combustion are dramatically reducing emissions of sulfur and nitrogen oxides. But it will be the transition to non-fossil-based sources that will make the permanent difference. Here, technological progress has been remarkable—with costs of solar generation of electricity falling by 95% in the past two decades—but not yet enough. Renewable energy continues to receive much too small a share of public research funds.

Technological innovation and application has also done much to make agriculture more productive. New technologies (many developed throughout the Consultative Group for International Agricultural Research [CGIAR] system) and increased fossil-fuel inputs have enabled a doubling of food production in the world in just 25 years, with >90% of this growth deriving from yield increases and <10% from area expansion. Dissemination of integrated pest management (IPM), and internalizing the environmental costs of biocide use, would enable biocide application to be cut dramatically with no loss of productivity (Pimentel et al. 1993).

Despite such remarkable progress, it is a mistake to base too much optimism on technological change. New technology is often adopted in order to improve labor productivity, which in turn can raise material standards of living, but without adequate attention to the environmental impacts of the manner in which the improvements are reached. The impact of a particular technology depends on the nature of the technology, the size of the population deploying it, and the population's level of affluence. The World Bank, along with others, is increasing investments in more sustainable technologies, such as wind and solar energy, which have limited or benign impacts on the relations of humanity to the ecosystem that supports us all.

But the level of affluence currently enjoyed by the citizens of the OECD countries cannot be generalized to the rest of the world's current population, much less the massively larger population of the developing countries 40 years from now, no matter what the improvements in technology are likely to be.

The contribution to approaching global environmental sustainability differs markedly in three geographic regions. OECD's main contribution to environmental sustainability should surely be to cease its long history of environmental damage from overconsumption and pollution (corollaries to affluence under today's technology), such as greenhouse warming and ozone-shield damage. The contribution of low-income countries lies in stabilizing the human population. The former centrally planned economies' contribution seems to be more in accelerating the modernization of its technology in order to reduce acid rain (by removing subsidies on dirty coal), to stop poisoning the land, to reduce waldesterben forest death, and to decrease nuclear risks.

It is in OECD's self-interest to accelerate technology transfer to the former centrally planned economies and to the low-income countries. But it is possible that with current types of technology and production systems the global economy has already exceeded the sustainable limits of the global ecosystem, and that manifold expansion of anything remotely resembling the present global economy would simply speed us from today's long-run unsustainability to imminent collapse. We believe that in conflicts between political feasibility and biophysical realities, the former must eventually give way to the latter, although we cannot specify exactly how long "eventually" will be.

A Dynamic Formulation: From Sustainability to Sustainable Development

The foregoing discussion of population, affluence, and technology, based on the Ehrlich and Holdren (1974) generalization can be nuanced. The inter-relationships among the three factors, and their links with shifts in the structure of the economy should be further disaggregated. Three trends need to be accelerated as we struggle towards sustainability.

First, given the political unreality of a voluntary decline in the overall affluence of industrial countries, how is the "pattern" of this affluence shifting? Specifically, is the economic structure of the economy shifting away from environmentally damaging activities (e.g., heavy and toxic industries) and towards less "natural capital-depleting" sectors (e.g., services)? This trend is to be encouraged, although some services deplete much natural capital (e.g., hospitals, hotels). Furthermore, while affluent Northern nations may be becoming less capital depleting by evolving into the service sector, at the same time much industry and other natural-capital-depleting activities are being transferred to developing countries. This is not a net gain for the sole global ecosystem, and may be a loss if developing countries' environmental standards are weaker than those whence the industries originated. Japan's huge success in using less input per unit of economic output, such as by de-linking energy and production, is based partly on the fact that most of Japan's aluminum, for example, is smelted overseas. Similarly, Japan's forest natural capital is almost entirely intact; practically all timber is imported. Recent research shows that structural shifts can have powerful impacts on natural-resource consumption.

Second, the clear trend in the consumption of natural resources per unit of output is improving in OECD and in places in developing countries. Two mechanisms need to be monitored here: improvements in economic efficiency (inputs per unit of output), and the degree of substitution away from environmentally critical inputs. Policy instruments, including taxes and user charges, can help promote such transitions, especially when the environmental costs are not captured in the marketplace.

Third, the pollution impact per unit of economic activity is declining in places; less so in others. Here it is important to distinguish between the innovation of new technologies, and their dissemination and application. Many of the most profound forms of environmental damage in today's world (soil erosion, lack of clean water, municipal waste, etc.) do not require new technologies, but simply the application of existing ones. This in turn requires (a) that decision makers are persuaded that the benefits of using such technologies exceed the costs, and (b) that resources are available for putting them in place. Public policies can be targeted towards meeting both conditions.

The availability of resources to implement more-sustainable strategies was a central argument in the findings of the Brundtland Commission's "Our Common Future" (World Commission on Environment and Development 1987), the United Nations Rio Earth Summit's "Agenda 21" (United Nations 1992), and the World Bank's *World Development Report 1992*. These documents and Goodland and Daly (1993) argue strongly that the reduction of poverty (i.e., empowering the poor with human and financial resources) is a sine qua non of sustainability. The point here is a crucial one: The clear goal of environmental sustainability needs the fuzzy process of environmentally sustainable development. The challenge is to distinguish between environmentally sustainable and unsustainable development.

Interactions among the driving factors—scale, structure, efficiency, technology, and investment in environmental protection—together with the key feedback loops between economic activity and human behavior, such as the powerful impact of income on fertility, explain why in some situations economic growth and technological progress will sometimes cause increased environmental damage and sometimes less. For effective policymaking, it is essential that these various paths be disentangled so that policies may be targeted in a manner that induces changed behavior away from environmentally damaging and inequitable growth and towards accelerated sustainable poverty reduction.

World Bank Progress Towards Sustainable Development

The World Bank's latest position on sustainable development has been published (Serageldin 1993*a*) so it will not be repeated in this conceptual paper. To summarize: an entire Vice Presidency for Environmentally Sustainable Development (ESD) was created in January 1993, and substantial numbers of staff (≈200 persons) are now focusing on sustainable development. ESD has started to integrate the viewpoints of the three relevant disciplines: economics, ecology, and sociology against which any technical/engineering proposals should be evaluated. ESD focuses on improved valuation of environmental concerns, building sustainability into national accounts, and how to value the future.

But beyond these conceptual concerns, the World Bank is actively pursuing a four-pronged agenda to promote ESD worldwide, through all its activities. This agenda comprises: (1) Assisting borrowing countries in promoting environmental stewardship; (2) Assessing and mitigating whatever adverse impacts are associated with Bank-financed projects; (3) Building on the positive synergies between development and the environ-

TABLE 2. World Bank lending for environmental management. (After World Bank 1993*a*.)

Country	Project	Loan/credit amount (10^6 U.S.$)
New commitments, approved in fiscal 1993		
Brazil	Water quality and pollution control—Sao Paulo/Parana	245.0
Brazil	Minas Gerais water quality and pollution control	145.0
China	Southern Jiangsu environmental protection	250.0
India	Renewable resources development	190.0
Korea, Rep. of	Kwangju and Seoul sewerage	110.0
Mexico	Transport air quality management	220.0
Turkey	Bursa water and sanitation	129.5
Total		1289.5
Projects under implementation, approved in fiscal 1989–1992		
Angola	Lobito-Benguela urban environmental rehabilitation (1992)	46.0
Brazil	National industrial pollution control	50.0
Chile	Second Valparaiso water supply and sewerage (1991)	50.0
China	Ship waste disposal (1992)	15.0
China	Beijing environmental (1992)	125.0
China	Tianjin urban development and environment (1992)	100.0
Côte d'Ivoire	Abidjan lagoon environment protection (1990)	21.9
Czech and Slovak Federal Republics	Power and environmental improvement (1992)	246.0
India	Industrial pollution control (1991)	155.6
Korea, Republic of	Pusan and Taejon sewerage (1992)	40.0
Poland	Energy resources development (1990)	250.0
Poland	Heat supply restructuring and conservation (1991)	340.0
Total		1439.5
Portfolio total		2729.0

ment (often called "win–win" strategies); and (4) Addressing the global environmental challenges.

Promoting environmental stewardship

When it comes to assisting countries in environmental stewardship, the Bank is helping in the definition of strategies and is providing funds for environmental management as well as for projects. In 1994 the Bank committed U.S.$173 × 10^6 in support of environmental management, bringing the portfolio of environmental management projects and project components financed so far up to ≈U.S.$500 million. This compares with a total portfolio of environmental loans amounting to ≈U.S.$5 × 10^9, of which about $2 × 10^9 were committed last year alone; details are provided in Table 2. In addition, the Bank is trying to help in the expansion and dissemination of knowledge by promoting the sharing of experiences among decision makers in the various countries. But sound environmental stewardship is rooted in sound development and environmental strategies, which must be based on properly identifying the right priorities, and these are country-specific.

The key point is that environmental priorities will vary from country to country, and the Bank should stand ready to assist each country with the design and implementation of its own environmentally sustainable development strategy. Each will have to address particular problems. Air pollution may be the prevalent issue in Mexico City (where the Bank is helping with a $280 × 10^6 loan), but there are other forms of pollution that could be a major priority in some other cities of the developing world. Toxic wastes are the most urgent problem in parts of the former Soviet Union. In Niger, it could very well be the problem of overgrazing. But whatever it is, the formulation of these national strategies, we believe, should be the result of a consultative participatory process in the countries themselves. That is how we expect that the National Environmental Action Plans (NEAPs), which are now being promoted in many countries, will be done.

Assessing and mitigating adverse impacts

The second part of the four-point agenda is assessing and mitigating unavoidable adverse impacts of projects that the Bank agrees to finance. This requires subjecting every proposal to a rigorous environmental assessment, as well as the traditional technical and economic assessments. Furthermore, the Bank is now trying to introduce social assessment as well. The Bank has published much on environmental assessment procedures (e.g., World Bank 1992*a*), so we will not go into detail here.

Building on "win–win" strategies

The third part of the four-pronged agenda is building synergies between development and the environment. The key here is that by adopting the conceptual framework of environmental sustainability, proper development helps environmental protection and vice versa. That is the so called "win–win" strategy, and it has two parts: investing in people and promoting the efficient use of resources.

Investing in people is particularly important. It is the poor who suffer the most from environmental degradation, especially women. When drought hits, it is the poor who suffer. Women are responsible for getting water, just as they have to gather fuel wood from farther and farther afield all the time, and they also care for the children. The solutions to better natural resource management as well as lowering fertility all involve empowering women. That means that investing in people, in human resource development, must pay special attention to girls' education. This is probably the single most important measure both for development and for the promotion of sound environmental policy over time.

Investment in people must also include population programs to recognize the pressure that the global population is putting on all of us, and these must be accompanied by the provision of maternal and infant health care and family planning.

The efficient management of resources is the second leg of the win–win strategy. Just how inefficient the current management of resources actually is can be quite striking. Sadly, a large part of this mismanagement is currently induced by government policy. Energy subsidies in the developing world account for U.S.$230 $\times$ 10^9 a year. That is about 4–5 times the total volume of official development assistance (ODA) going from the North to the South. Water, biocides, and fertilizer also are subsidized. That is environmentally unsound and economically wasteful of resources that could be invested in better uses.

Likewise, many of the subsidies that exist today are, in fact, for extractive and destructive industries. In the case of logging, for example, average stumpage fees are a fraction of the cost of reforestation. Among African countries sampled in 1988, the best amounted to less than one quarter of the cost of reforestation, while the worst was running at about 1% of the cost. So subsidies were going to private loggers whereas, in fact, the full restitution to the public commons was not taking place.

We have focused here on developing-countries problems because this is where the World Bank lends. Nevertheless, the Bank is equally concerned about the inequitable use of resources worldwide and the wasteful and destructive practices being pursued by Northern consumption and pollution patterns, and is trying through reports and discussions to help develop the requisite awareness in the North.

Addressing global challenges

The fourth part of our four-pronged agenda is addressing global challenges. Here, we include national activities that have global payoffs. These are areas where much can be done to promote the global agenda from a national, sovereign, decision-making framework. There are, of course, global issues where the costs are local and the benefits are global. For these activities special investment and financing instruments like the Global Environmental Facility (GEF) have a crucial role to play. The GEF has also been designated as the interim funding mechanism for the two United Nations conventions on Biodiversity and Climate Change.

In parallel to working on these global population challenges, the World Bank is also concerned with consumption in the North, and how to address the disparities between the North and the South. It is important to remind ourselves—as the United Nations Development Programme's Annual Human Development Report did so eloquently in the now famous "champagne glass" graph—that the richest 20% of the world's population receive ≈83% of the world's income; The poorest 20% receive 1.4%. That means a huge disparity, both in terms of consumption patterns and in terms of pollution. This argues for sound strategies for people in the South because they have so few degrees of freedom, but it also certainly argues for looking again at the consumption patterns in the North. And by that, we do not mean going back to the horse and buggy days. Switzerland, which by no stretch of the imagination is a deprived country, has a water consumption per capita that is about one fifth that of the United States. On energy consumption levels, the Swiss (and the Japanese, for that matter) use about one-half what each U.S. citizen does. The per capita consumption of energy in India or China is still a very small fraction of that in Switzerland or Japan. So per capita consumption issues have to be looked at, and these argue for changes in the Northern patterns, as much as they argue for sound practices in the South.

The same is true in terms of the global commons, and the contribution on the debit side in terms of pollution and the use of the environment as a "sink." The contribution in terms of CO_2 emissions, or in terms of global waste production and pollution show the same types of disparities. They are also very large. India's per capita contribution of average annual tons of carbon emitted into the atmosphere is very small compared to Canada or the United States, and this is true of most developing countries, except for the former USSR, where levels are relatively high because of the nature of their industrial activities.

Such disparities encourage one to think in terms of tradeable permits. Low-income countries with a large population could trade permits based on proportional population rights to use environmental services (both to consume and to pollute) with some of the richer countries. While this is not currently on the agenda of international negotiations, there is something there for all of us to reflect on.

In addition to the agenda described above, the Bank has substantially increased direct environmental investments (e.g., Table 2): a record U.S.$2 $\times$ 10^9 for 23 projects to assist developing countries in improved environmental management. This represents a doubling of the amount of 1 yr ago, and a 35-fold increase over lending 5 yr ago. Financing for the enabling conditions of sustainability also soared: $\$180 \times 10^6$ for population, $\$2 \times 10^9$ for education, $\$5 \times 10^9$ for poverty alleviation. In addition, >30 countries have prepared national environmental action plans with assistance from the Bank. The Bank is convinced that environmental sustainability is essential, and costs less than unsustainable development.

A major obstacle to promoting policies that foster sustainability to date has been the incomplete measurement of income and investment, particularly the failure to reflect the use or deterioration of natural capital (Steer and Lutz 1993). To correct this failure, the Bank is promoting improvements in the United Nations System of National Accounts (SNA) (Ahmad et al. 1989, El Serafy 1993, Lutz 1993). Environmentally adjusted SNA has massive policy implications for most developing countries. Economics Nobel Laureate Robert Solow has recently modified his 1973 position that natural capital is unimportant: "The world can, in effect, get along well without natural resources" (Solow 1974:11). In 1992 he concluded that the U.S. gross domestic product (GDP) may change only 1–2% if environmentally adjusted (Solow 1992). Perhaps this seems a small concession, but during the discussion period of his 1992 Resources for the Future lecture he recognized that developing countries rely to a vastly greater extent on natural capital than does the U.S. Without environmentally adjusted SNA, we cannot judge if an economy is genuinely growing or merely living unsustainably on asset liquidation beyond its true income, whether the balance of payments is in surplus or deficit on current account, or whether the exchange rate needs to be changed.

Conclusion

This paper represents our current views on the concept of environmental sustainability. This is ongoing work, part of which is being done in the World Bank, and much of it being done by concerned scholars around the world. Our aim has been to make a modest contribution to the debate on the essence of sustainability. We fully expect the concept to be refined in the coming months and years. By its actions, it is clear that the World Bank is taking environmental sustainability seriously indeed. But this conceptualization is far from an academic exercise. The monumental challenge of ensuring that possibly 10×10^9 people are decently fed and housed within less than two human generations—without damaging the environment on which we all depend—means that the goal of environmental sustainability must be reached as soon as humanly possible.

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